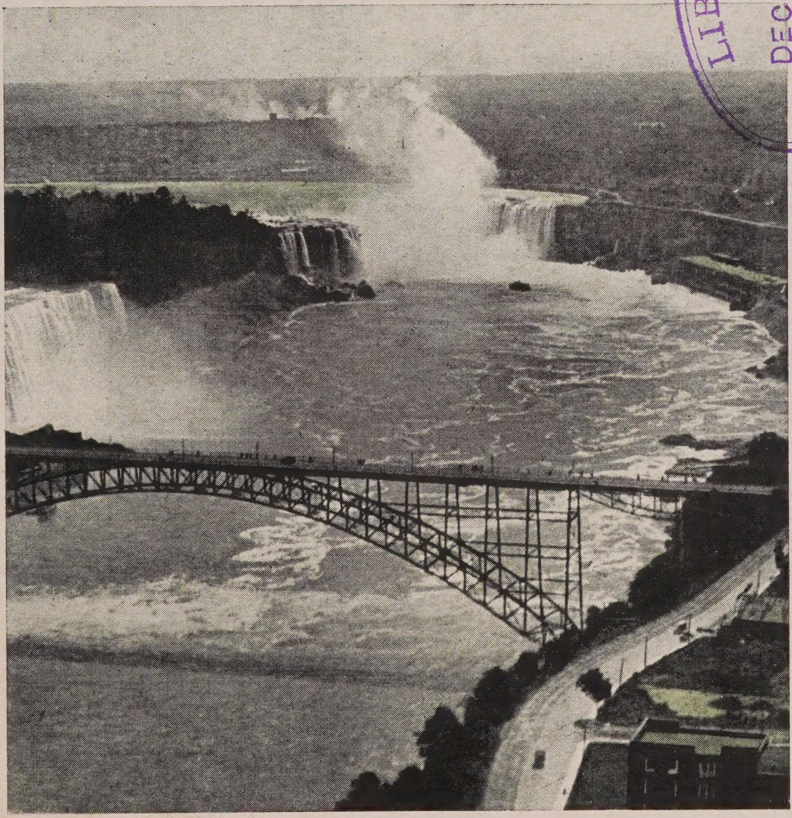
THE BULLETIN

Vol. VII. No. 8

Hydro-Electric Power Commission of Ontario

OCTOBER 1920



Niagara Falls from the Air

THE

BULLETIN

PUBLISHED MONTHLY BY THE

Hydro-Electric Power Commission of Ontario

ADMINISTRATION BUILDING
190 UNIVERSITY AVE.
TORONTO

SUBSCRIPTION PRICE:
TWO DOLLARS PER YEAR

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VOL. VII. No. 8
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The Design of the Queenston-Chippawa Power Canal

By T. H. Hogg, A.M.E.I.C.

Assistant Hydraulic Engineer, Hydro-Electric Power Commission of Ontario

THE power canal for the Queenston - Chippawa Development is one of great interest both from the economic as well as from the hydraulic side. A history and detailed account of the design will not be given in this paper but rather a general description of the economies and hydraulics of the canal that is under construction, together with certain details of the methods that were employed in attacking the problems of design.

The canal is divided into four sections, a profile and typical cross-sections of which are shown in Figure 1. The first of these is the Welland River section 21,000 feet in length, with a bottom slope 0.000119 and side slopes of 2 to 1. This is being excavated by means of dipper dredge and cableway. The earth section which follows the river section is 6,250 feet long with a bottom slope of 0.0001208 and is to be rip-rap lined with finished side slopes of 1.5 to 1. For each of these sections a roughness factor of .035 in Kutter's formula was used. The earth section of the canal was originally designed as a concrete lined section of much smaller cross-sectional area but a study of the economic, constructional and operating conditions indicated the advantages of the larger section with the rip-rap lining would be sufficient to compensate for the cost of the extra excavation. This portion of the canal has a capacity of over 15,000 c.f.s. with uniform flow at the assumed roughness factor of 0.035, and extreme low water in the Niagara River at Chippawa.

At the end of the earth section is located a transition 300 feet long in which the trapezoidal cross-section is changed to the rectangular rock section of 48 feet finished width with concrete sides and bottom. Beyond this are the control works, which are described in the paper by M. V. Sauer, M.E.I.C.

The rock section proper is 36,252 feet long and is divided into two parts by the Whirlpool section which has a length, including transition, of 2,450 feet. The rock portion of the canal has the water section with concrete lined sides and bottom with a finished width of 48 feet. The bottom slope is 0:0002113 and the roughness factor used in Kutter's formula 0.014. This value is conservative in view of the proposed method of placing the concrete lining. With the steel forms that are to be used and the special provisions being made for alignment of the forms, a smooth plane surface will be obtained on the concrete facing.

Paper read at the General Professional Meeting, E.I.C., September 17, 1920.

For 13,500 feet the concrete lining will be carried up 32 feet above the finished grade of the canal, for the next 11,500 feet the lining will be 31 feet high, and for the remainder 30 feet high, except in the Whirlpool Section, where it is carried up to elevation 563.0. For the greater part of the time the water surface will be above the top of this concrete lining but the friction loss will be reduced by the lower velocities that will then exist in spite of the greater roughness of the unlined rock. Numerous hydraulic studies have been made to determine the surface slopes in the canal for various discharges and for various water levels in the Niagara River. In cases where the water surface was above the top of the concrete lining a composite roughness factor was used in which the proportions of the wetted perimeter on the lining and on the rock surface were taken into account. Roughness factors as high as 0.019 resulted in some of these instances.

Determination of Depth and Slope

The depth and slope of the rock section were fixed by an economy study, and the decision to use a concrete lining throughout its length was also reached in the same way. The method of arriving at the economic section of the canal will be explained later.

An examination of the profile of the canal (Figure 1) indicates that the rock surface falls far below the grade of the canal about Sta. 333, rising again to grade about Sta. 349. This occurs in the Whirlpool Section, which is located at Bowman's Ravine or the Whirlpool Gully. Here it is

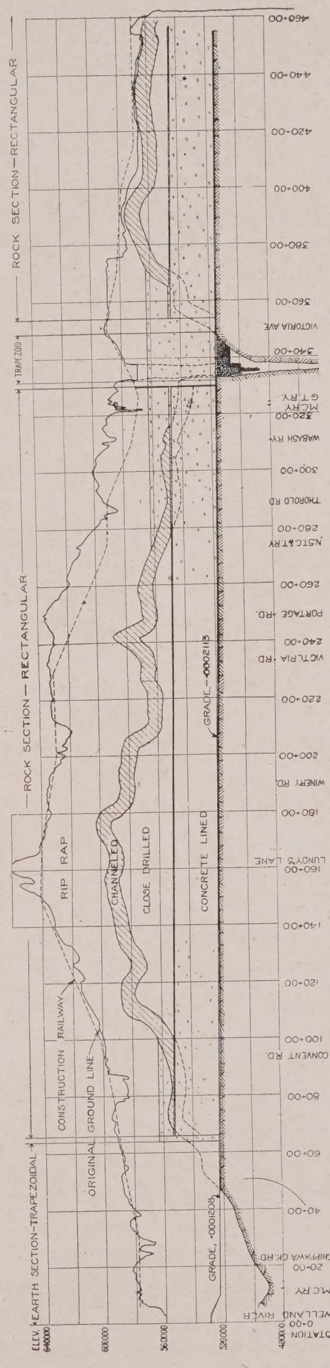


Figure 1

necessary to carry the canal partly on fill and to use a trapezoidal cross-section on account of the foundation upon which the canal is carried. A concrete lining is essential on account of the high velocities. The cross-section is shown in Figure 1, where it will be seen that the bottom width is 10 feet and the side slopes 1½ to 1. The slope of the bottom is the same as that of the rock section, *viz.*, 0.0002113.

The Whirlpool section of the canal was designed to have the same cross-sectional area at the lowest possible operating water level as that of the rectangular rock section. This minimum water level would be somewhat above elevation 542, which is the elevation of the curtain wall at the screen house. The area of the cross-section below elevation 542 is the same for both, and for greater elevations the Whirlpool section has the greater area, so that there is no danger of the canal capacity being "choked off" at this point.

In locating the Welland River section the river course was closely followed so as to take advantage of the area of the natural channel. This necessitated leaving in, all the bends that occurred in the unimproved stream. As the deflection of these curves is not great, they will not produce any appreciable loss.

The first important change in direction occurs at the beginning of the earth section at Montrose, and is followed by a second bend at the Michigan Central Railway crossing at Montrose. In addition to these, there are only five changes of direction in the rock section of the canal, the deflections of which are 51°, 27°, 31°, 33° and 46°. The radius of curvature in every case is 300 feet, and this radius is used for the inside and outside of the bend as well as for the centre line. That is, the curves of the two sides and the centre line of the canal are not concentric, resulting in a greater width of canal at the middle of the bend than at either end, the expectation being that the energy losses will be less than in a bend with concentric curves. It is probable that a shorter radius than 300 feet would give even better results, but this minimum was fixed by the size of the electric shovels that are being used for the excavation of canal.

The question of surges of the water surface in the canal, due to changes of load on the plant, is of great importance. This problem has received an amount of study proportionate to its importance, but on account of the limited space of this paper, it will be sufficient to say that the sides of the canal and the floor of the screen house will be built to such an elevation that with the worst combination of conditions the water will always be contained within the sides of the canal.

Observations of river stage at Chippawa have been available since 1902, and show a minimum W. S. elevation of 558.5, which low stage was reached only on two days. An examination of the past records of Lake Erie stage indicate that as low a stage as 558.0 may be possible at Chippawa. This latter water level is therefore treated as extreme low water, and the canal is designed to carry full load at this stage of the river.

While the low water conditions control the size and slopes of the canal,

on the other hand the mean water conditions were assumed to be those on which the economic proportions should be based.

Design of Canal Section

Certain limitations were met with at the outset. The Welland River section of the canal had to be maintained as a navigable stream, and as the excavation is in earth this portion of the canal was therefore designed for a low non-scouring velocity. The minimum width of the rock section was fixed by the type of electric shovel used for excavating this portion of the canal and was placed at 48 feet.

The problem thus resolved itself into selecting the best proportions for the trapezoidal earth section and the best depth and slope for the 48 foot rock section. The procedure in the latter case is the one that will be described.

It is, of course, possible to design any number of canals 48 feet wide, but with depth and slope varying so that all will give the same discharge at low water. For a low velocity the wetted cross-section must be deep, but its slope may be moderate. For a high velocity the depth of the wetted cross-section will be small, but the slope may be so great that the depth of the cut at the down-stream end may be greater and the total cost of excavating greater than for the low velocity design.

The procedure in determining the economic depth was as follows:

First, the design of a number of cross sections for velocities of 3, 4, 5, etc., feet per second, the determination of the requisite slope of the bed in each case to give the full load discharge with uniform flow, and the determination of the variation in cost of these canals with low water velocity.

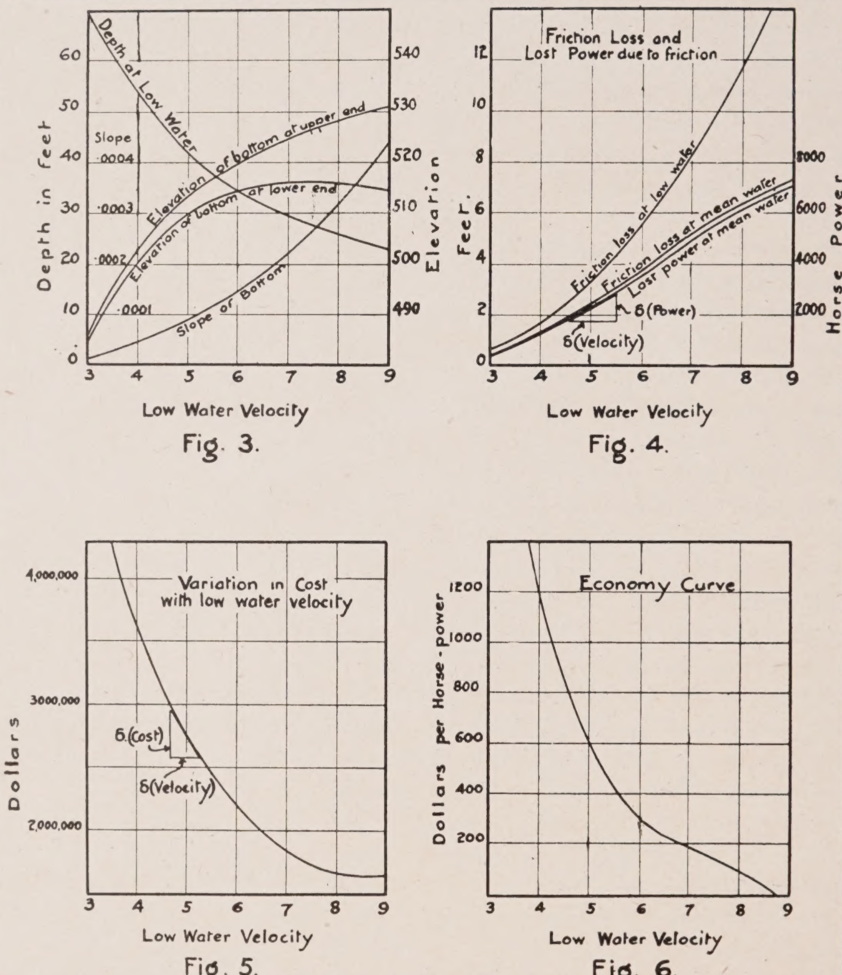
Second, the determination of the friction loss in each of these canals with the river stage at its mean value. This friction loss represented so much lost power, which was, of course, small in amount for the lesser low water velocities, and greater as the low water velocity increased up to a certain point.

Third, the plotting of the differential curves for items 1 and 2 thus showing the *variation* in delta cost with low water velocity and the variation in delta power with low water velocity. From these two differential curves a third curve can thus be obtained giving the value of delta-cost by delta-power plotted against low water velocity. Thus there is obtained what will be called an economy curve, showing for any given low water velocity, the rate at which further gains in power may be made at any low water velocity by enlarging the canal slightly and so cutting down velocity and friction loss.

Fourth, the selection of the best low water velocity from this economy curve. This step will now be explained.

The gain in power which results from a slight enlargement of the canal comes as a result of the reduction in friction loss. The additional cost for power house equipment is so small, within the limits in which we are working, that they can be neglected. It is reasonable then to continue the enlargement of the canal until the interest charges on the cost of exca-

vation for the last horse power gained are equal to the average value of the power from the whole plant, including interest, depreciation, operation and maintenance. By stopping short of this point we would be in a position to gain more power at a cost less than the average that we were willing to pay for the power from the whole plant. It is interesting to note that the economic velocity determined in this way is but slightly greater than the minimum cost at which the canal could be built to get the required dis-



H·E·P·C
QUEENSTON CHIPPAWA DEVELOPMENT
CANAL - ROCK SECTION
ECONOMIC STUDIES

charge at low water. The minimum cost occurs for a velocity somewhat greater than the economic velocity.

The advantage for this method of attack is that it permits an economic size to be selected for the canal without the inclusion in the estimate of the cost of anything that does not vary with the low water velocity. In this case, the width of the rock cut being fixed, the earth excavation does not vary with the various designs for the rock section and as a matter of fact in computing the cost of rock excavation only that below some assumed horizontal plane at a lower elevation than natural rock surface but above canal grade, was considered.

Figures 3 to 6 illustrate a typical economic canal study. The studies from which these figures are taken were for a canal of small capacity and greater roughness than the one being built, so that the curves show the method only and do not apply to the present canal.

Figure 3 shows the results obtained in designing for various low water velocities. These designs can be made only when a previous study for the earth section has been completed, so that the elevation of water surface at the end of the earth section is known.

Figure 4 shows friction losses and lost power due to friction. The method of obtaining the first derivative of the lost power curve is also indicated.

Only the variation in cost, not total cost, is shown in Figure 5. It is evident that the shape of this curve is the same whether we include the whole cost or only that part which varies with low water velocity. In either case the first derivative will have the same value.

The determination of the form of the economy curve Figure 6 is explained above.

The procedure in the economic design of the earth section of the canal was similar to that for the rock section but somewhat more complicated by reason of the fact that certain changes in the design of the earth section involved changes in the excavation throughout the length of the rock section. The difference in procedure was thus largely a matter of properly taking care of all the variations in cost.

It is the intention at a later date to present a complete detailed description of the methods and analyses used in determining the various hydraulic features of this work. At that time there will be submitted the calculation covering the economics and hydraulic characteristics, so that these may become a permanent record for use on similar work.

Canada's agricultural, dairy and animal industry products for 1917 totalled $1,222,831,000.

There are 3,774 grain elevators in Canada, five of which are Government owned.

Canada is Britain's largest overseas Dominion.

There has been a steady increase in the production of coal in Venezuela for several years.

Hydraulic Installation of the Queenston-Chippawa Development

By M. V. Sauer, M.E.I.C.

Hydraulic Engineer of Design, Hydro-Electric Power Commission of Ontario

THE purpose of this paper is to describe briefly the pertinent features in the hydraulic installation of the Queenston-Chippawa Development with a short discussion of the reasons that led to the various designs adopted. On completion of the work and after the plant has had a thorough workout, it is expected that a paper will be presented to The Institute covering in fuller detail the complete layout, with a full comparison of the results obtained in operation as against those predicted in the design and determined by the various mathematical analyses employed therein.

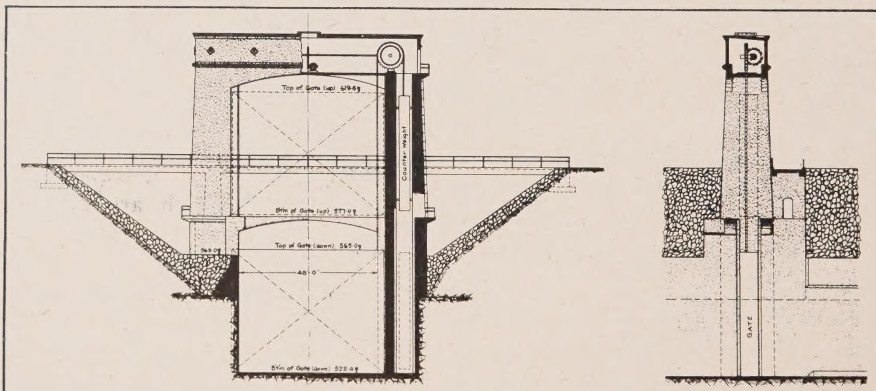
Paper read at the General Professional Meeting, E.I.C., September 17, 1920.

The features to be touched on in this paper cover:

Canal Control Gate,
Ice Chutes,
Screens,
Removable Gates,
Penstocks,
Johnson Valves,
Turbines,
Governor System,
Control Pedestals,
Service Units.

Canal Control Gate

A single motor-operated vertical lift roller gate for the purpose of controlling or entirely shutting off the flow will be installed at the upper end of the canal near Montrose, where the earth section of the canal merges into the rock section. The combination of span and head make this gate the largest ever built, and particular at-



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QUEENSTON-CHIPPAWA
DEVELOPMENT
CANAL CONTROL GATE

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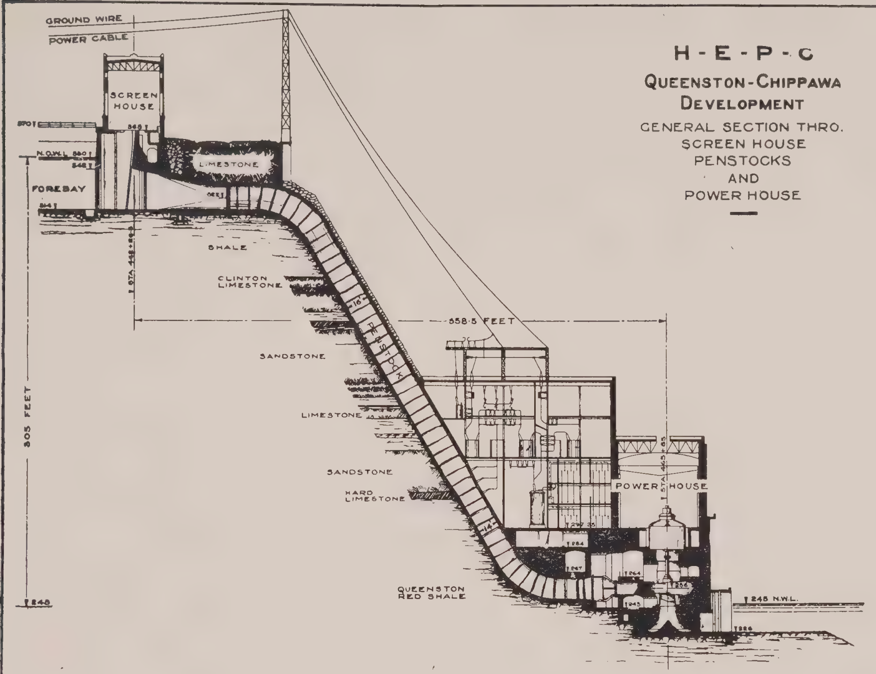
FIG. 1



A-1103

FIG. 2

tention is being paid to the roller design in order to secure bearing loads well within safe, structural and operating limits. The clear width is 48 feet and the height of the gate is 42½ feet.

The general arrangement of the control gate is shown in Figure 1. It will be noted that the lift is extended to a point 14 feet above the water level and this has been done in order to permit a patrol tug to pass freely up and down the canal when the gate is in normal position, *i.e.*, wide open.

The gate will be counterweighted and operated by a motor connected through a worm drive to the two main hosting gears, and the motor will be provided with distant as well as local control so that the gate can be operated from the power house if required.

The gate itself will be made up with horizontal trusses spanning the opening and vertical beams to which the skin plate will be rivetted. It is not important that the gate be absolutely watertight when closed, although "stanching" bars will be provided to insert between the skin plate and the end guides, which will make it practically tight.

A comparative analysis of costs and operating conditions was made on the single gate as against two gates with an intermediate pier, and it was found that the cost of a single gate and superstructure did not exceed the cost of the twin gates, on account of the additional construction required by the intermediate pier and the necessary widening of the canal to keep down the velocity to normal. When the added advantage of having a clear

unobstructed waterway was taken into account as well as the simplified operation of a single gate in place of two, the decision was entirely favorable to the single large gate.

ICE CHUTES

It is expected that the intake as designed will take in water from the Niagara River, absolutely free from floating ice, but to take care of any ice that may form on the surface of the canal or the Chippawa River channel a small ice chute is being provided at the lower end of the forebay. It consists simply of an opening through the screen house provided with a drop gate which can be lowered below the water surface for a depth of 12 feet. The discharge over the gate is carried through the screen house and down the cliff and under the power house to the lower river in a reinforced concrete pipe 10 feet in diameter.

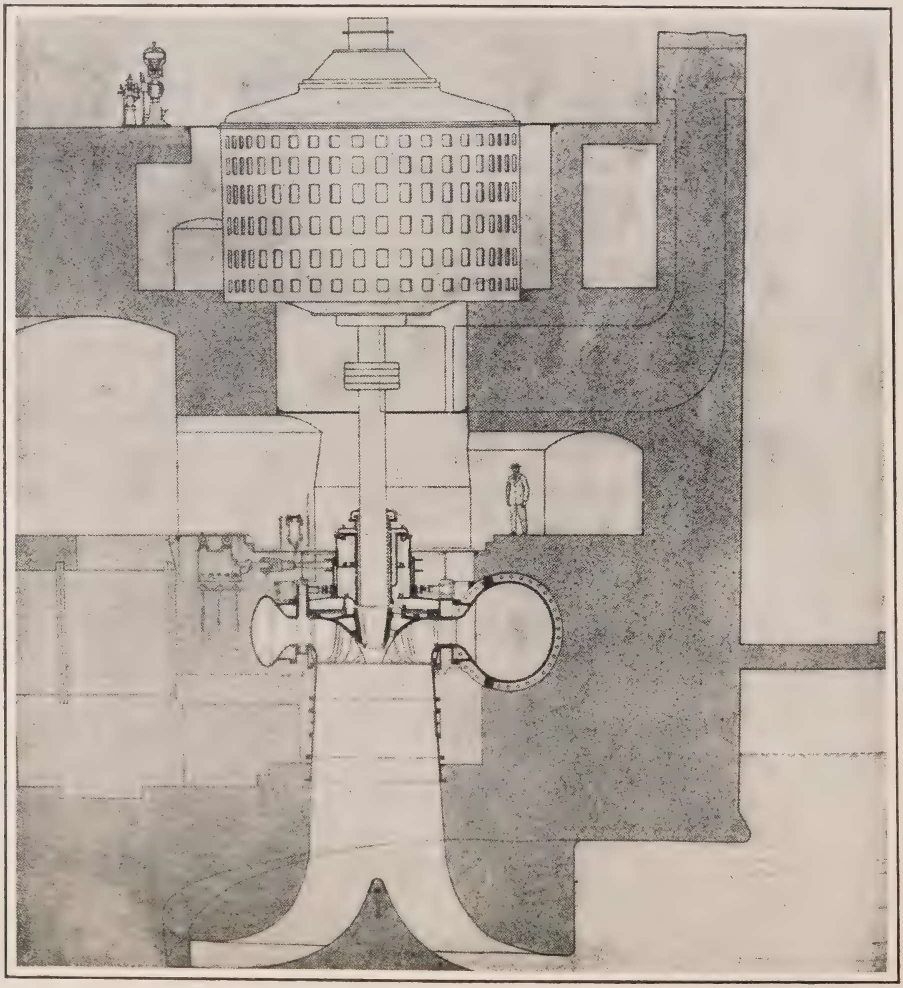


Figure 3—Section through Power House

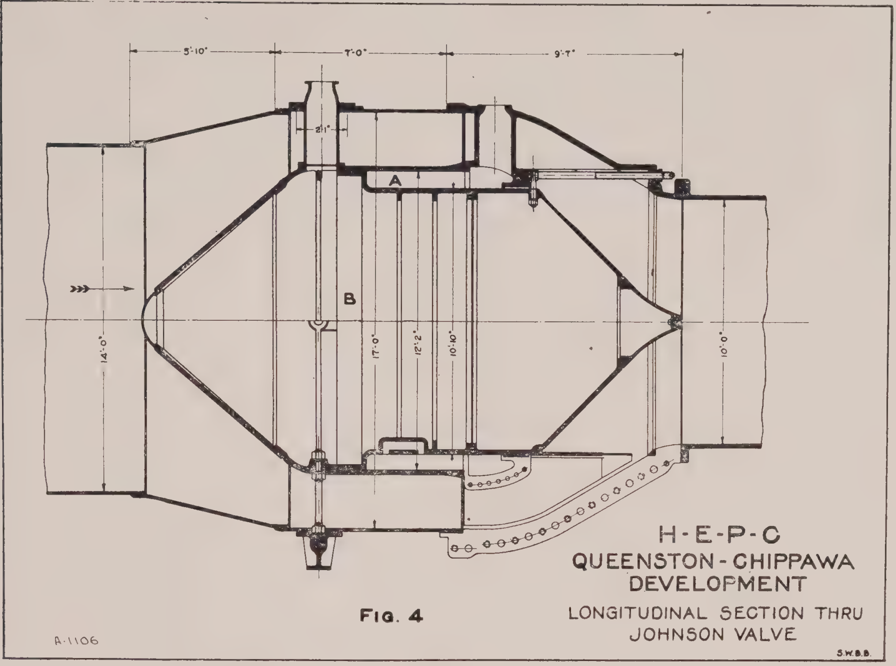


FIG. 4 LONGITUDINAL SECTION THRU JOHNSON VALVE

An elaborate design of ice skimmer has been made up which, if found necessary, can be installed later on. This consists, in general, of a reinforced concrete horizontal pivoted leaf which can be raised or lowered in accordance with the water stage so that floating ice will be skimmed off the surface to a discharge channel, at the same time allowing the clear water to pass underneath. Provision is now being made in the outer wall of the curve in the canal immediately above the forebay so that this skimmer can be installed in the future if it is found that sufficient capacity is not provided in the smaller ice chute through the screen house.

Screens

The only features of the screens worthy of comment are the wide bar spacing of 4½ inches in the clear and the layout of the bars and frames which are so designed that the whole frame with the bars attached is removable, thus leaving a completely unobstructed passage when they are removed. There are three bays of screens for each penstock, and two frames in each bay. The tops of the screens are eight feet below the normal surface of the water, and the maximum velocity of water through the screens is 2.25 feet per second. With these provisions it is not anticipated that anchor ice will cause much trouble.

Removable Drop Gates for Penstocks

In view of the fact that a Johnson valve is to be installed at the lower end of each penstock adjacent to the turbine, it has been decided to omit permanent gates in the screenhouse at the penstock entrances. To take care of any failure in the valves, re-

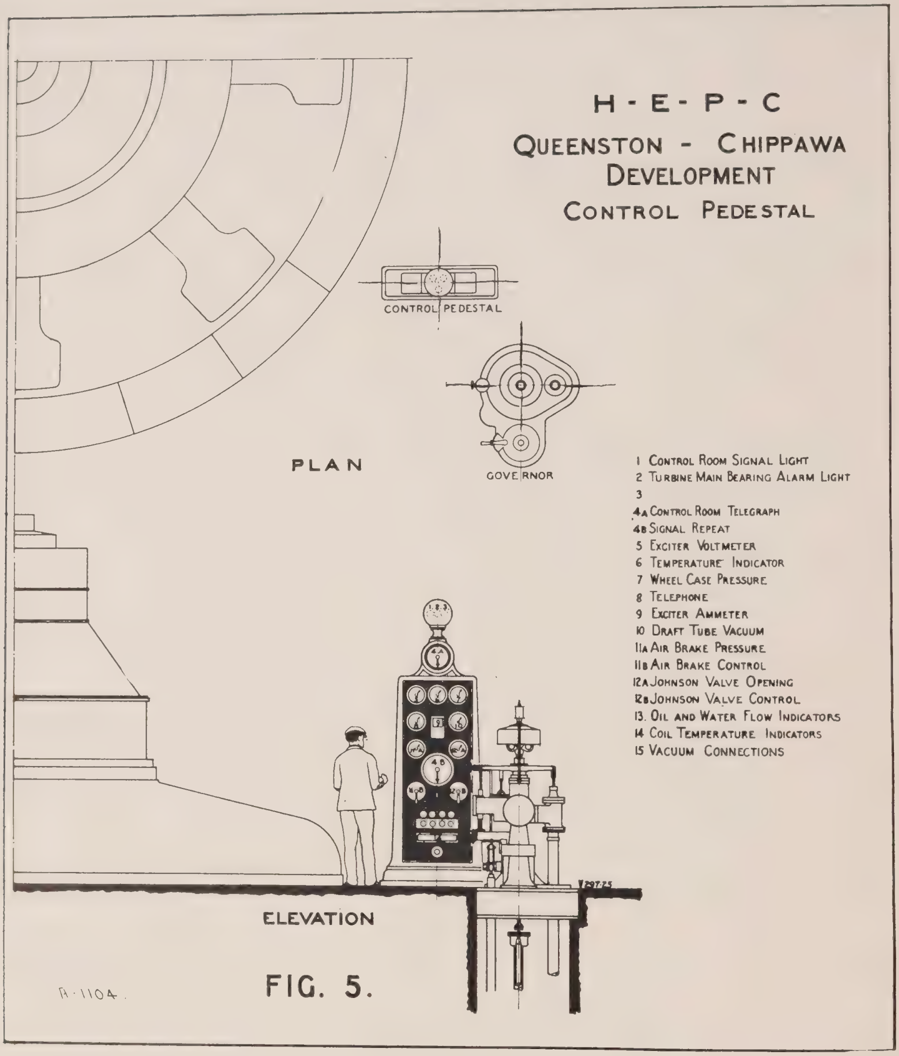


FIG. 5.

movable structural gates, made up in sections, will be provided which can be lowered into any penstock entrance by means of an electric travelling crane in the screenhouse.

PENSTOCKS

The quantity of water used by each turbine at full load and under normal head is approximately 1,800 cu. ft. per second, and in the design of the penstocks, the diameter was fixed by plotting up various curves showing the value of lost power due to varying velocities and their consequent friction losses as against the carrying charges on the corresponding penstocks. By this means a diameter of approximately 15 feet was found to give the best value, but so great a diameter at the lower end required a plate thickness of over 1½ inches, and this was considered beyond the limit

for safe field rivetting. On this account the diameter of the upper two-thirds of the pipes was made 16 feet and the bottom third 14 feet, which made the construction work feasible and at the same time gave the desired economical results. The total loss through the screens, penstocks and valves is 1.25 feet, using a value of C = 110 in the Hazen & Williams formula. The loss is considerably reduced by the use of butt girth joints with an outside cover plate as against the customary practice of using inside and outside courses.

Johnson Valves

Figure 4 shows a longitudinal section through the Johnson hydraulic operated valves, which are located at the lower end of the penstocks. The operation of these valves is very simple, no outside power being required, the valve being opened or closed by means of the penstock pressure. The valve plunger is of the differential type and seats against a ground fit ring in the neck of the body. The annular chamber A. and the central chamber B. are connected through a control valve and piping either to the penstock pressure or to the atmosphere. Admitting pentock pressure to A. and atmosphere to B. opens the valve, while the reverse operation closes it.

The advantage of a valve of this type is the simplicty of operation. Furthermore, because of its circular section it can be built for any head and thus located at the lower end of a penstock, obviating by this arrangement the necessity of emptying and filling the penstock for each shut-down.

Turbines

Five turbines are at present under contract, which is one-half the ultimate installation. They are each of 50,000 h.p. rated capacity of the vertical, spiral case, single runner Francis type and will operate at a speed of 187½ r.p.m. This gives a specific speed of 36. The maximum guaranteed efficiency is 90%, although in view of recent practice it is expected that this efficiency will be exceeded. On model runners of homologous design tested at Holyoke, 91% was obtained. The inlet diameter of the scroll case is 10 ft. and the diameter of the runner is 10 ft. 5 in. at the inlet. Figures 2 and 3 show the turbine setting and it will be noted that an open space has been left in the power house foundations below the runner so that by removing a section of the draft tube the runner can be taken out from below, thus obviating the necessity of dismantling the generator when a renewal of the runner is necessitated. The runner is designed for a capacity of 61,000 h.p., and is "gated back" to a maximum capacity of 55,000 h.p. The reason for this is that the turbines, which will normally operate at or near full rated load, will also, therefore, operate at their maximum efficiency. Special taps have been provided in the crown plate and from the annular spaces around the discharge side of the runner, to which gauges can be attached and a record kept of the varying pressures at these several points. This will furnish an indication of the wearing away of the runner seal and show when renewals of seal rings are necessary. Connections from these chambers to the scroll case and draft tube

will allow readjustment of the downward thrust when required.

The runners and spiral casings are cast steel and a test pressure of 260 lb. per sq. inch is required in the latter.

Governor System

The centrifugal head, relay valves, and hand control for each governor will be located on the generator floor, while the main automatic valve control will be located directly under the governor stand at the level of the turbine regulating cylinders. The advantages of this arrangement are the short piping between the main valve and the regulating cylinders and the separation of the two main parts of the governors, giving freer access for repairs and maintenance. The pressure fluid will be water, probably treated with bichromate of potassium, which will prevent rusting of the wearing parts and at the same time give a lubricating value to the water. A central pumping system will be used, with duplicate motor driven multi-stage centrifugal pumps, either one of which will have sufficient capacity for all the governors. The pressure fluid will be piped to all the governors through accumulator tanks, one located near each governor, so as to eliminate any inertia effects through the piping system. The pump motors are automatically controlled by relay switches which are controlled by pressure variation in the system. As a further safeguard for preserving continuous operation, in the event of failure of the pumps or motors, penstock pressure can be turned into the governor system. When the plant is finally extended to its full capacity a complete duplicate pumping system, similar to the one above described, will be installed and interconnected with the present system.

Control Pedestals

A control pedestal as shown in Figure 5 will be set up adjacent to each generator, and on this will be mounted the various indicating instruments and control handles shown on the diagram. The principal use for such an arrangement is that the communicating devices between the floor operator and the chief operator in the control room, together with the local control and indication, will be located in such a way that the floor operator can handle the machine while in touch with the chief operator.

A telegraph communication, similar to a ship telegraph, and a loud talking telephone, both communicating with the control room, will form the principal means of communication. In addition to this, a signal lamp mounted at the top of the column over the control pedestal, will enable the chief operator to call the floor operator to the unit as required. The air brake and Johnson valve control will also be mounted on this pedestal. The location of this pedestal adjacent to the governor places the control of all the pertinent features of the unit within easy reach of the operator, while at the same time he will be in communication with the control room. The various indicating instruments shown will at the same time be under his observation.

Service Units

For furnishing heat, lights, and power service to the plant, two service units, each of 2,500 h.p. capacity, will be installed. Each of these consists of a vertical turbine running at

500 r.p.m., direct-connected to a generator. The turbines are supplied by a single 5-foot diameter penstock branching into two pipes at the turbines, each branch being provided with a Johnson valve. It is expected that the service plant will be duplicated when the power house is completed to its full capacity.

The General and Economic Features of the Queenston-Chippawa Development

By H. G. Acres, M.E.I.C.

Hydraulic Engineer, Hydro-Electric Power Commission of Ontario

ALTHOUGH the active promotion of the Queenston - Chippawa Power project commenced in 1914, it was not until 1917 that the grave power shortage, created by the demand for munitions and war materials, reached such proportions that the then existing government authorized the commencement of actual construction. At this time a shortage of skilled and common labor had manifested itself, the cost of labor, plant and construction materials was rising rapidly, and conditions on the whole were such that the undertaking of this project could not have been justified wholly as a commercial venture. On the other hand, the Allied Nations were in the midst of a bittle struggle, which at that time might well have been expected to last for another five years or more. With this possible, it was generally conceded that the resultant exhaustion of man-power would transform the final stages of the struggle into a war of munitions, with a resultant imperative demand for large additional supplies of electrical power for their manufacture. It was therefore evident that if 200,000 horsepower could be made available through the agency of the Queenston-Chippawa Development by the year 1921, a factor would be introduced which would have a vital bearing on the success of the Allied arms. For this reason the construction of the Queenston - Chippawa Development was undertaken primarily as a war measure.

When, however, the crisis of the war passed in July of 1918, and peace came in the following autumn, it became necessary to reconsider the status of the project, and transform it as far as possible from a war scheme designed to meet an urgent and immediate need, to a commercial scheme, embracing as many as might be of the elements of true conservation and an ultimate maximum of economy in the production of power. Space is not available to cover the steps of this transformation in detail, suffice to say

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Paper read at the General Professional Meeting, E.I.C., September 17, 1920.

that it resulted in the final development as it stands to-day, with permanent works designed for the installaton of plant up to an aggregate of 500,000 horsepower capacity, whenever the necessity arises, as dictated by the public need.

Selecting a Location

From the combined viewpoint of conservation and ultimate economy, the ideal Niagara Development would be one which would utilize the whole of the future available water under the gross head of 327 feet existing between Lake Erie and Lake Ontario. Several schemes, approximating this ideal in varying degree, have been advanced during the last 20 years, and of these the most practicable and promising was one, known as the Jordan-Erie scheme, which involved the intaking of water near Morgan's Point on Lake Erie, the building of an open waterway across the Niagara Peninsula to the brink of the escarpment above Jordan Harbor, thence carrying the water to the power-house at Lake Ontario level through a mile of pipe. Studied from an engineering standpoint, this scheme was open to serious objection for three main reasons; first, the unfavorable intake conditions at the Lake Erie end; second, the structural difficulties and unavoidable head loss in connection with the 24-mile canal; and third, the regulation difficulties attendant upon the control of a mile long water column in the penstock connection between the head of the canal and the power-house, where something over 16 feet of penstock would be necessary for each foot of effective head. The economic effective head for this scheme worked out slightly less than 300 feet, the bulk of the losses being, of course, taken up in the long canal.

The problem was, therefore, to find if possible some feasible location which would obviate the main objections to the Jordan-Erie scheme. During the course of the subsequent investigation, it developed that by far the best intake conditions would be obtained at the mouth of the Welland River at Chippawa; and also that suitable power-house locations were obtainable in the gorge between Foster's Flats and Queenston, which would require only about 18 inches of penstock connection for each foot of effective head, thus reducing the regulation problem to one of minor importance. Figure 1 illustrates the comparative layout and location of these two schemes.

Pressure Canal versus Open Canal

Having tentatively solved the intake and regulation problems, it remained to determine whether or not it was feasible to construct a suitable waterway between the Chippawa intake and the power-house location above Queenston. An exhaustive series of surveys and core-drill borings established the fact that it would be entirely feasible to connect these two points by either the open canal or the pressure tunnel type of waterway, and the next problem was to determine which of these two types of waterways would be the more suitable from the combined viewpoint of pure hydraulics, structural difficulties and hazards, and comparative cost.

In the matter of comparative cost, carefully compiled estimates indicated that throughout the full range of assumed carrying capacities, the open

canal had a decided advantage over the pressure tunnel.

PRESSURE TUNNEL DISADVANTAGES

In the matter of structural difficulties and hazards the following main points were given consideration in the case of the pressure tunnel:

(a) The necessity of driving the headings at an acute angle through the various limestone, shale and sandstone formations, involving the certainty of a heavy overbreak and expensive timbering and lining.

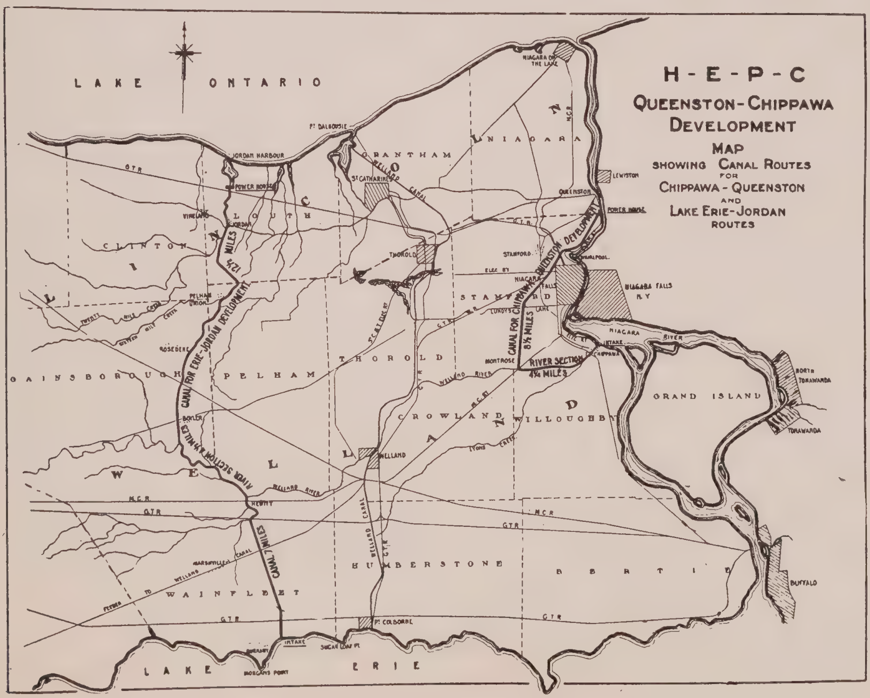
(b) The unfavorable conditions as regards the disposal of excavated material.

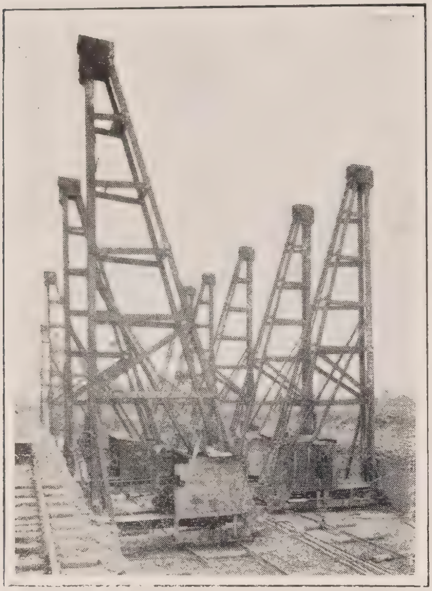
(c) The unknown water hazard and the impossibility of predicting the cost of unwatering within reasonable limits of accuracy.

(d) The difficulty and hazard attending the driving of, and maintaining, a pressure tunnel of unprecedentedly large diameter in the clay formation of the Whirlpool Ravine.

(e) The difficulty in connection with the construction of a distributing chamber in the shale and sandstone at Queenston.

As against the above, the difficulties and hazards in the case of the open canal were limited to two main points: first, the removal of the earth overburden in the canal prism, and, second, the permanent holding of the slopes subsequent to such removal. While it may never be possible to establish finally the comparative importance of the above points on the basis of actual construction, the fact remains that the work already accomplished on the open canal has demonstrated beyond doubt that the overburden can be removed with no more





Battery of Marine Drills Sta. 391 + 44, June 1, 1920

difficulty than was anticipated and that the means originally devised will hold the banks safely within the limits of the predetermined slopes.

Hydraulic Comparisons

In the matter of purely hydraulic comparisons, the first point to consider is that both types of waterway of necessity would have the same point of intake at Chippawa and the same point of discharge at Queenston, so that they are exactly on a par as regards the utilization of available gross head, neither having any primary advantage over the other in this regard.

Since 1902 the water level at Chippawa has been observed and recorded twice daily, and Figure 2 shows the mean daily elevations for the ensuing period compiled in the form of a duration curve. The following facts are deducible from this curve:

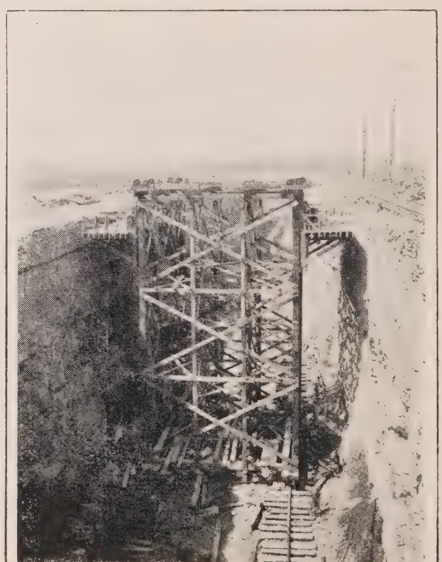
(a) The mean level for the entire period is about elevation 560.8.

(b) A level of elevation 559.5 or higher is obtained for nearly 99% of the entire period.

(c) A level of elevation 561 or higher is obtained from a little more than one-third of the above period.

(d) That it is reasonable to assume that the effective operating range of levels lies between elevations 5569.5 and 561.

As to the possibility of the carrying capacity of either type of waterway being seriously affected by a permanent lowering of the natural levels of the Chippawa-Grass Island pool, due to present and future diversions of water therefrom, it is essential to consider two facts: first, that any diversion for power purposes from the pool itself will be largely compensated for by the intercepting effect of the diversion works, and, second, that the level



Travelling Derrick in Canal at Sta. 451 + 5, May 6, 1920

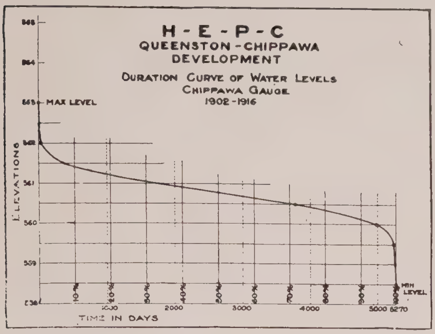


Figure 2

of the pool can be controlled independently to compensate for any diversion whatever, whether from the pool itself, from the upper reaches of the river, or from Lake Erie direct.

In Figure 3 an effort has been made to show in graphic form a comparison of the head losses chargeable to each type of waterway under discussion. In making this comparison, a possible extreme low elevation of 558 has been assumed for head-water, and the open canal losses calculated on this basis for a carrying capacity of 15,000 sec. ft. On the basis of this loss a tunnel was designed of the requisite diameter for the same capacity of 15,000 sec. ft.

These curves have been computed for the extreme range of possible operating levels, elevations 558 minimum and 561 maximum. The shape of these two pairs of curves illustrates clearly the basic difference between the two types of waterway. Under the assumed conditions the tunnel and canal curves for the head-water elevation 558 and 15,000 sec. ft. discharge have a common point of origin. As the discharge drops off, however, it is seen that the canal delivers any fixed discharge to the forebay at a consistently higher elevation than in the case of the tunnel. This is simply due to the inherent characteristics of the two types of waterway. In the case of the pressure tunnel, the discharge area is necessarily constant and any gain in head is due to decreased friction only. In the case of the canal the reduction in velocity not only reduces the friction losses, but the retardation of flow increases the effective discharge area of the canal section. By reason of this extra factor, the open canal has an advantage over the tunnel ranging as high as 5 feet of head loss. When the high discharges involved in the problem are considered, it is evident that this difference in head loss is a very important factor.

The curves shown on Figure 4 have been plotted on a different basis, but with the same factors involved. In Figure 3 head-water level and carrying capacity have been assumed constant and forebay level the variable. In Figure 4 head-water and forebay level are the constants and carrying capacity expressed in horsepower is the variable. In this latter curve forebay level is assumed constant at the fixed minimum elevation for peak load capacity and from this common point the comparative carrying cap-

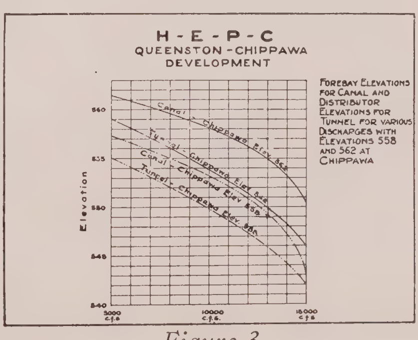


Figure 3

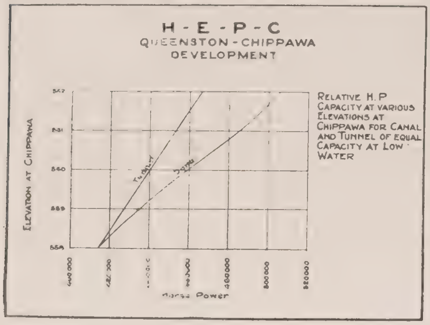


Figure 4

acities of the two types of waterways have been calculated for specified levels of head-water in the Chippawa-Grass-Island Pool.

Here again the two curves have a common point of origin at the point of extreme minimum capacity, but from this point on the canal characteristically pulls away as the head-water level rises, until at the maximum operating level of elevation 561 the canal has an advantage over the tunnel of 30,000 horsepower in carrying capacity. This gain is due to the fact that the tunnel can only realize the gain of a trifling increase in gross head, and a resultant trifling increase in pressure gradient, as the level of head-water rises, whereas the canal gains a material increase in natural gradient and effective discharge section. This increase in carrying capacity is, therefore, gained by the canal without any reduction of operating head at the forebay, whereas the tunnel can gain the extra capacity only at the expense of a reduced operating head.

Conclusions Favor Open Canal

The conclusions which may justifiably be drawn from the above discussion are: first, that starting from the common basis of equal loss and carrying capacity at extreme minimum head-water level, the open canal will deliver the required quantity of water to the forebay with a materially less loss of head than the pressure tunnel, for any head-water level above the assumed absolute minimum; second, that starting from the common basis of a fixed minimum forebay level, the canal will deliver a constantly increasing quantity of power in proportion as the level of head-water rises above the assumed extreme minimum level, which the pressure tunnel cannot do to any appreciable extent by reason of its inherent hydraulic characteristics; and finally, that the open canal is the only agency, under the above conditions, which can make automatically available the large quantities of excess power resulting from any temporary or permanent increase in the level of the Chippawa-Grass Island Pool, above the extreme minimum level which has been used as a basis of comparison.

The above were the primary reasons which led to the final choice of the open canal for the connecting waterway between Queenston and Chippawa. This canal as now being constructed, consists of 4¼ miles of the improved natural channel of the Welland River and 8½ miles of dry excavated section from a point on the Welland River near Montrose to the forebay site above Queenston. Beside being only about half the length of the alternative Jordan-Erie Canal, the average operating head for equal quantities of water carried is about six feet greater at Queenston that it would have been at Jordan Harbor, despite the fact that the elevation at the point of intake is about 9 feet

lower, and the elevation at the point of discharge about 2 feet higher, than would have been the case with the Jordan project.

Another distinct advantage of the open canal is the fact that it can effectively and inexpensively take advantage of any water which might now or in the future be available from the Welland Canal system. This open waterway would furthermore furnish the only means, in connection with the upper reaches of the Welland River, of reclaiming the unused 9 feet of head in the Niagara River above Chippawa. This would involve a very heavy expenditure, but the value of power will not always be judged by present standards, and the time may well come when this extra power may be considered worth reclaiming at a capital cost per horsepower ten times greater than is considered justifiable at the present time. These are more or less remote contingencies, but the fact remains that the choice of the open type of waterway, and the layout of the rest of the scheme, will enable effective advantage to be taken of these conditions whenever the public need may become sufficiently acute. When this happens the extreme limit of conservation will have been realized in the matter of utilizing the gross difference in level between Lake Erie and Lake Ontario, and the anticipatory provision made in the present design will have justified itself.

Public Benefit from the Power Project

In considering this phase of the problem, it should be realized that under co-operative municipal ownership, a block of power delivered to the outgoing lines at Niagara is not valued by what it can profiably be sold for at so many dollars per horsepower

Shovel No. 1, Canal Excavation, looking south at Curve Sta. 443, February 5, 1920

per annum, but by what it means to the individual citizen as an agency for increasing his comforts, conveniences and general standard of living and for facilitating increased commodity production. Such conditions tend toward the building up of the greatest asset any country can possess, an increasingly prosperous and contented population. The influence of Niagara Power on the wealth and prosperity of the community at large will, therefore, be measured more effectively by the maximum amount of power which can ultimately be produced and utilized, rather than by considering the power itself as the ultimate commodity which is to be produced as cheaply as possible in limited quantities and sold at a corresponding profit. In other words, the secondary profit derived from a widely diversified use of power throughout the community must take precedence over any primary profit derived from its direct sale as a commodity, if the true interests of conservation are given proper weight.

It is not within the scope of this article to cover any details of design, construction methods and installation, but as regards the canal, the most vital feature of the plant design, original methods of attack were devised, with the assistance of R. D. Johnson, which involved an interesting application of the graphic calculus. This in turn led to a similar application of the graphic calculus to the penstock design and a practically rational method was devised for determining the economic diameter.

Capacity of Units

The decision to fix capacity of the units at 50,000 rated horsepower was governed by three primary considerations; first, the rapidly increasing demand for power necessitated the development of power in blocks of a magnitude not hitherto conceived; second, by reason of the economy in first cost which results from making the capacity of the individual unit a maximum for any given head; and third, because the lineal power-house space in the gorge was limited, having regard to tail-water levels and the possibility of further extensions.

As the design now stands, each unit comprises about 10 per cent. of the ultimate installed capacity, and the power-house will contain something over 900 horsepower of effective capacity per foot of length, a figure which has not hitherto been approached, as far as is known.

Summary of Construction Methods

In conclusion, it might be of interest to make some reference to construction methods and to summarize briefly the reasons which lead to the adoption of the type of construction plant which is now operating on the work.

A careful study of construction methods in connection with the excavation of earth and rock in the canal was necessary by reason of certain existing conditions which would have a vital influence upon excavation cost. These conditions were: first, the availability of cheap electric power for operating construction plant; second, the large quantities of earth and rock to be removed, which made it possible to consider the use of excavating machinery of the heaviest type and largest capacity obtainable; and third, the unusually good facilities

Shovel No. 2 opposite Sta. 267 + 57, looking south, May 5, 1920

available for the disposal of spoil, within short hauling distance, along the crest of the Niagara escarpment.

Having the above conditions in mind, the Commission's engineers spent several months in collecting and studying data in connection with the type of construction plant required. The operation of electric and steam driven excavating machinery was witnessed and studied in various parts of Canada and the United States, and a large amount of information with reference to output, operating cost, working conditions, etc., was obtained and carefully analyzed.

The most important decision arrived at in connection with the purchase of this plant was that with reference to the use of the largest type of shovel that could be obtained. These shovels are removing the full depth of overburden while working from solid rock against a face averaging 45 feet in height, with a maximum of 80 feet. It was furthermore necessary to use these shovels in the rock cut, where they are lifting and loading into cars 65 to 70 feet above shovel grade. The rock cut, being only 48 feet wide, would not permit the carrying of loading tracks down to a sufficiently low elevation to reach the loading range of an ordinary railroad shovel, and it is certain that excavation by clam or drag-line would have very materially increased the cost and seriously delayed the date of completion of the rock work.

In the earth work it was demonstrated beyond any doubt that on the bulk of the work railroad shovels would have been useless on account of the soft bottom and on some sections of the work it is doubtful if the overburden could have been removed

Rock Walls before Scaling South to Sta. 443, June 1, 1920

by any possible means other than by these large shovels working from rock.

The economy of this construction plant is rather plainly indicated by the fact that in 1917, when work commenced with railroad type shovels, direct labor cost comprised 29% of the total unit cost of excavation. To-day, with labor costing 250% more than in 1917, the labor cost per yard of excavation has only increased 4% over the 1917 figure of 29%. This would appear to indicate that the saving of man-power resulting from the use of the large excavating units has practically off-set the 250% increase in labor expenditure. In the month just past (July) 500,000 cubic yards of earth and rock were removed and finally disposed of in 26 working days, with a total working force of 2,000 men, not more than half of whom were engaged in the direct excavating operations. These two facts alone would indicate that the type of construction plant on the Queenston-Chippawa work has fully justified the decision which led to its adoption and that the results being achieved would not otherwise have been possible.

The wheat crop of Canada for 1920 is estimated at 275 million bushels, as compared with a total of 196,361,000 bushels in 1919. One hundred million bushels will be required to feed the people of Canada and to seed Canadian farms. The rest will go abroad to feed no fewer than 28,000,000 people for a whole year.

The Automobile Headlight Problem

By Geo. G. Cousins

Illumination Laboratory, Hydro-Electric Power Commission of Ontario

INTRODUCTORY.

THE intensive use of artificial light is one of the many products of our advanced civilization that, while being a powerful agent for the benefit of the human race, is at the same time responsible for a heavy toll of life and limb. This is particularly true in connection with industry and transportation. Insufficient light and faulty distribution of light are the prolific causes of accidents in both industry and transportation. During recent years the relation of light to industrial accidents has been closely studied with the result that the number of such accidents has been materially reduced by the proper application of light. A similar result can be expected from a study of the lighting problems of transportation, particularly that phase of it that is effected by the headlights of automobiles—which are responsible for a very large proportion of the accidents occurring at night in the streets and roads of the country. Much has been done in the way of enacting legislation for the regulation of automobile headlights so as to render their use safe for all concerned.

The Province of Ontario has enacted and put into force a law which places limits on the candlepower of the headlight beams when measured above the horizontal and which requires certain minimum values for the portions of the beam at or below the horizontal. These tend to minimize the danger from glare and to provide sufficient light on all parts of the road to allow drivers to avoid collisions and ditches.

In cities and towns the regular street lights are usually sufficient to provide for safe driving when the headlights are dimmed. Nevertheless, many drivers do not dim their lights and the glare is more or less present when there is no excuse for its existence. It is when cars are driven beyond the range of street lights and must of necessity carry their own street lighting systems that the problem becomes serious.

Requirements

On country roads cars are usually driven at high rates of speed at night and the exact nature and condition of the roads are not always known to the drivers. Many of the roads are narrow and there is the ever present ditch at the side. To make driving safe the driver must be able to recognize ruts and obstructions in the road in time to avoid them and must be able to see how much space there is at the side to turn into when passing another vehicle coming in the opposite direction.

These requirements demand fairly powerful beams of light projected far ahead of the car and spread a few degrees to the sides. In obtaining these conditions consideration must be given to any person driving a car or other vehicle in the opposite direction so that the vision of the oncoming driver is not seriously interfered with because of temporary blindness caused by looking into powerful beams of light. Such temporary blindness very often places a driver in a very dangerous situation and many accidents are directly the result of this. It is a generally conceded fact that very little light is required above the horizontal and the unreflected light from the lamps is usually sufficient.

With the parabolic reflectors regularly furnished on cars, and standard types of lamps ample light is generated to satisfy any reasonable demand and the problem is to so distribute this light that as large a percentage of it as possible is directed into useful zones and is utilized to illuminate the roadway and its immediate surroundings.

Characteristics of Parabolic Reflectors.

Parabolic reflectors are very efficient devices for projecting light from a small lamp for considerable distances. When the lamp is adjusted so as to produce the highest concentration of light in the beam the light is confined to a small angular spread. A pair of such beams tilted so that the upper edge is aproximately horizontal gives a fairly satisfactory driving light for straight roads. The small spread is a disadvantage as it leaves the sides of the road in comparative darkness and to offset this disadvantage the use of the spot-light is resorted to.

The Spot-Light.

The value of the spot-light as an accessory to the main driving light is questionable. At best it only illuminates a small area rather close to the car and is useful in assisting a driver to pick his way along a bad stretch of road. It is also useful in illuminating road signs and street numbers. When used for the latter purpose it must be subject to the control of the driver and this constitutes the greatest objection to its use. A driver who is courteous will not subject anybody to its blinding rays but there are many who consider themselves only and these are no doubt responsible for the strong prejudice against the free use of this device. As to whether or not its advantages overbalance its disadvantages is an open question. It is a significant fact that in several of the States, in the United States, where the regulation of headlights is strict, the spot-light is prohibited. Reference to to efficacy of the spot-light as a driving light will be made later.

Specifications for Road Performance.

Considerable difference of opinion exists as to what constitutes the best driving light and until this is determined any specifications can at best be but a compromise. A few years ago the Automobile Headlighting Committee of the Illuminating Engineering Society undertook to collect opinions and data on the whole subject of automobile headlighting. Questionnaires were sent to a large number of men who were qualified to express opinions and the answers were classified. This was followed by an extensive series of road tests which were participated in by representatives of motor associations and others concerned. A number of cars were used and their headlight conditions were varied and measurements of beam candlepower were made after each alteration so that the exact conditions were known. Observers were stationed on the road so as to record their impressions of approaching headlights, whether they were glaring or otherwise. Other observers were seated in the cars and recorded when sufficiently powerful beams were produced to reveal obstructions and ditch locations. From these tests it was learned that the candlepower in the direction of the observers of the highest recorded tolerable glare was 800 and that the lowest candlepower sufficient to reveal the location of the ditch was 1,200. From these and other data secured the committee was able to form a fair idea of what was required to illuminate the road properly and to limit the candlepower above the horizontal where the light might interfere with other users of the road.

A consideration of these facts should serve to prove that the specifications are based upon actual driving requirements and are not the result of mere theorizing.

The main features of the specifications are given below:

I. Performance on the Road.

For the purpose of the test the intent of the law governing the headlights of motor vehicles other than motorcycles and tractors is deemed to be complied with if so adjusted, arranged and operated as to meet the following conditions:

1—Any pair of headlamps under the conditions of use shall produce a light which, when measured on a level surface on which the vehicle stands at a distance of 200 feet directly in front of the car and at some point between the said level surface and a point on a level with the centres of the lamps, is not less than 4,800 apparent candlepower.

2—Any pair of headlamps under the conditions of use shall produce a light which, when measured at a distance of 100 feet directly in front of the car, and at a height of 60 inches above the level surface on which the vehicle stands, does not exceed 2,400 apparent candlepower, nor shall this value be exceeded at a greater height than 60 inches.

3—Any pair of headlamps under the conditions of use shall produce a light which, when measured at a distance of 100 feet ahead of the car, and 7 feet or more to the left of the axis of the same, and

a height of 60 inches or more above the level surface on which the vehicle stands, does not exceed 800 apparent candlepower.

4—Any pair of headlamps under the conditions of use shall produce a light which, when measured on a level surface on which the vehicle stands at a distance of 100 feet ahead of the car and at some point between the said level surface and a point on a level with the centres of the lamps and 7 feet to the right of the axis of the car is not less than 1,200 apparent candlepower.

II. Laboratory Tests of Headlighting Devices.

By headlighting device is meant either the integral and complete headlamp or a device intended to modify in a suitable manner the beam of the ordinary type of headlighting equipment.

A pair of testing reflectors, mounted similarly to the headlamps of a car, shall be set up in a dark room at a distance of not less than 60 feet nor more than 100 feet from a vertical white screen. If a testing distance of 100 feet is taken, the reflectors shall be set 28 inches apart from centre to centre, and if a shorter testing distance is taken the distance between reflectors shall be proportionally reduced. The axes of the lamps shall be parallel and horizontal, or tilted in a vertical plane in accordance with manufacturer's adjustment. The intensity of the combined light shall then be measured with each pair of samples in turn, with the reflectors fitted with a pair of each of the following types of incandescent lamps in turn:

(1) Vacuum type, 6-8 volts, 15 scp.

(2) Gas-filled type, 6-8 volts, 21 scp.

The lamps shall be adjusted to give their rated candle power at rated efficiency. Measurements shall be made at the following points at the surface of the screen.

A. In the median vertical plane parallel to the lamp axis on a level with the lamps.

B. In the same plane one degree of arc below the level of the lamps.

C. In the same plane one degree of arc above the level of the lamps.

D. Four degrees of arc to the left of this plane and one degree of arc above the level.

E. Four degrees of arc to the right of this plane and on a level with the lamps.

F. Four degrees of arc to the right of this plane and two degrees of arc below the level of the lamps.

In an acceptable device both pairs of samples shall conform to the following specifications for observed apparent candlepower:

Points A and B—At at least one of these points, or at some point between them, the apparent candlepower shall not be less than 4,800.

Point C—The apparent candlepower shall not exceed 2,400.

Point D—The apparent candlepower shall not exceed 800.

Points E and F—At at least one of these points, or at some point between them, the apparent candlepower shall not be less than 1,200.

Figure 1 shows the relative positions of the 6 test points and seen by a driver seated in a car. The targets shown are placed 100 feet from the headlights of the car and the points

E and F and D are placed 7 feet from the centre on either side.

The specifications adopted by the Department of Highways of the Province of Ontario are the same as those described above.

TESTS.

To carry out the tests required accurate photometric electrical measuring instruments are essential. The lamps used in the headlights have to be measured to determine at what voltage and current they must be operated to produce their rated candlepower. These lamps have to be checked frequently so that any changes due to deterioration are detected. On account of the completeness of such equipment in regular use at the Laboratories of the Hydro-Electric Power Commission we were asked by the Department of Highways to undertake the testing of the head-lighting devices according to the above specifications.

A pair of headlights with reflectors of 8½ inch effective diameter, specially made for this purpose, are mounted so that they can be tilted up or down and deflected sideways any required amount. The reflectors are the same as those regularly supplied except that they are more accurately made and more highly polished. An extra lamp adjusting device was also applied to enable any eccentricity of lamp filaments to be compensated for.

The headlights are mounted upon a horizontal bar at the required distance apart. A telescope is mounted between them with its axis parallel to those of the headlamps. The headlamps and telescope are rigidly connected so that they move together. Provision is also made for special tests that may require one headlamp

Figure 1—Location of test points.
NOTE—*This is* NOT *an illustration of excellence of beam control.*

Figure 2—Standard Headlamps.

to be tilted more than another. In such a case the telescope can be aligned parallel to either headlamp axis and any fixed position may be maintained between them and the whole tilted or deflected as a unit. Protractors are provided for each headlamp and for the horizontal rotation. Figure 2 shows the testing headlamp with the necessary electrical connections set up for test. Each lamp is provided with means of independent adjustment. Figure 3 shows the screen on which the beams of light are trained. The six test points are located on this screen in an inverted position for reasons that will be explained. The test plate of the photometer is located at A which is the central point of the pair of headlight beams in the normal position. The photometer is mounted on the back of the screen with its test plate flush with the face. A black spot is seen on each side of the centre. These spots are in line with the axes of the headlamps to assist in making accur-test the lamps are adjusted to produce ate adjustments easily. In making a the proper type of projected beam and the device to be tested is put in place. The telescope (connected to the headlamps) is sighted upon the point A (the photometer test plate) and a measurement of the combined candlepower of the beams is made. In order to measure the candlepower at the point B, which is 1 deg. below the horizontal, either the photometer must be lowered or the beams raised. The latter method is used and the beams are elevated until the point B of the beam is at the test plate. In this position the telescope is sighted

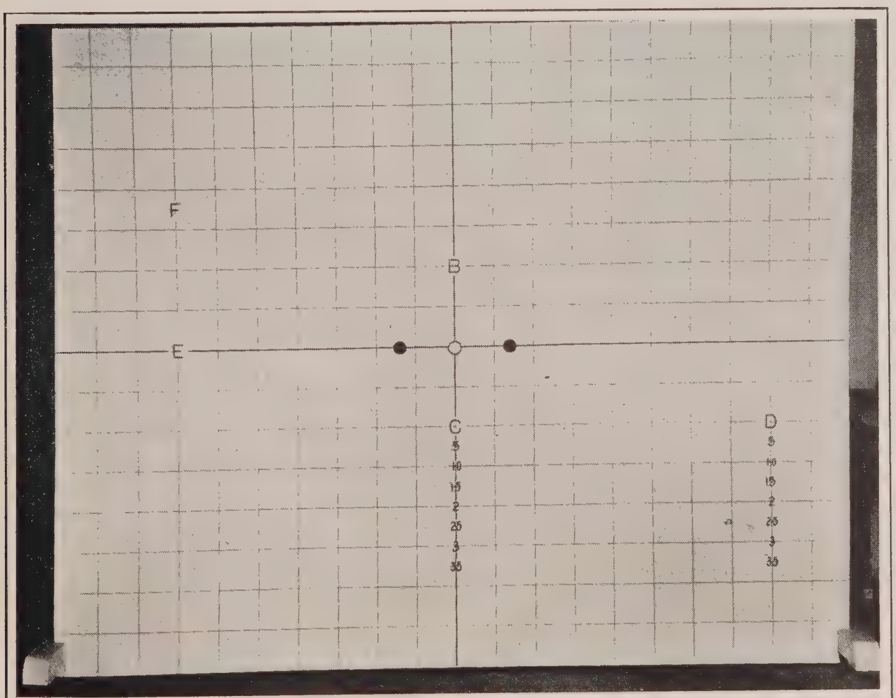


Figure 3—Test Screen (front).

upon the point above the horizontal which is marked B. In the same way the other points of the beams are measured. The points C and D are the glare points and if the candlepower at these points exceed the limits, the beams are tilted downward ½ foot at a time and measurements are made until the limits are not exceeded, if this is possible. These ½ foot points are shown below C. and D. If the measured values of candlepower below the horizontal are lower than required, no adjustment can be made to raise them without changing C. and D. A determination is made of the maximum candlepower permissible to use with each device to conform to the specifications. Figure 4 shows the back of the screen with the photometer in place.

Lamp Adjustment.

The importance of correct lamp focusing cannot be over emphasized as the best device may give very unsatisfactory results if the lamps are not properly focused. In every case the manufacturer's instructions for adjusting each device should be followed. In some cases it might be a little difficult to decide on what is the best adjustment (or focus) of the lamp because the beams have not got sharply defined edges. The adjustments are as a rule simple and a few trials should enable anybody to produce satisfactory results. The greatest difficulty likely to be encountered is with lamps whose filaments are not located in the centres of the bulbs.

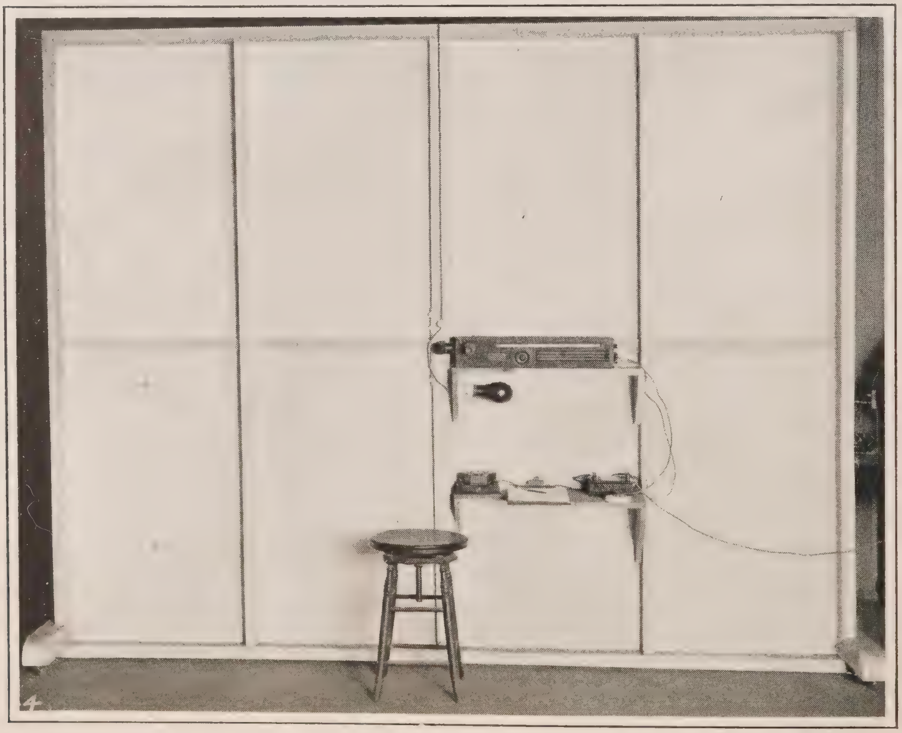


Figure 4—Rear of Test Screen, showing Photometer.

Characteristics of Devices.

The average public mind endows light with all sorts of mysterious and magical properties and it is looked upon as something that can be magnified and amplified without limit. It is not surprising therefore to find devices that are practically worthless clothed with wonderful powers. These are designed without any knowledge of the laws of optics.

The majority of the devices submitted are of the prismatic lens type. No two makes are alike but the principal of using prisms to deflect the light downward and vertical prisms or cylindrical lens sections to spread the beam sideways is the basis of their operation. Many of these utilize the light in a very efficient manner and produce excellent road illumination that should satisfy any reasonable demand without the use of the spotlight. The best types produce 4 to 5 times as much light on the road as is required by the specifications without exceeding the glare limit.

The value of this type of device lies in the utilization of practically all of the beam. That above the horizontal is deflected down on to the road.

Another very satisfactory type of device is that which utilizes half of the beam. The other half being absorbed. The degree of spread to be obtained with these is more limited than is produced with some of the prismatic lenses but nevertheless when properly adjusted furnish good driving light far in excess of the requirements of the specifications. Furthermore, they reduce the glare to a negligible quantity especially when the upper part of the beam is screened off. If the upper part of the beam is screened off the lamp is placed behind the focal point of the reflector and if the lower part of the beam is screened the lamp is placed in front of the focal point.

There are several ways of accomplishing the result just described: by painting or frosting half of either the front glass, the bulb or the reflector or by placing screens over half of either the lamp or the reflector.

Although only half of the beams are used with the type of device just considered this half beam is utilized very efficiently on account of the clear glass offering very little obstruction to the passage of light.

Painting the upper half of the clear glass front of the headlamp produces as good driving light as any device of this class. In this case the lamp should be placed behind the focal point of the reflector. The adjustments of the lamps with this type of device is best done after the device is in place. Project the light onto a vertical surface such as wall, 25 or more feet away. Cover up one headlight while the other is being adjusted and adjust the lamps so that the upper half of the beam is cut off on a horizontal line.

Diffusing glasses or devices cannot comply with the specifications because half of the light is above the horizontal and sufficient light cannot be produced on the road without producing a similar amount where it will shine into the eyes of persons facing the car.

Metallic louvres, vanes and gauze have not been found to produce any useful modification of the bear, with one possible exception.

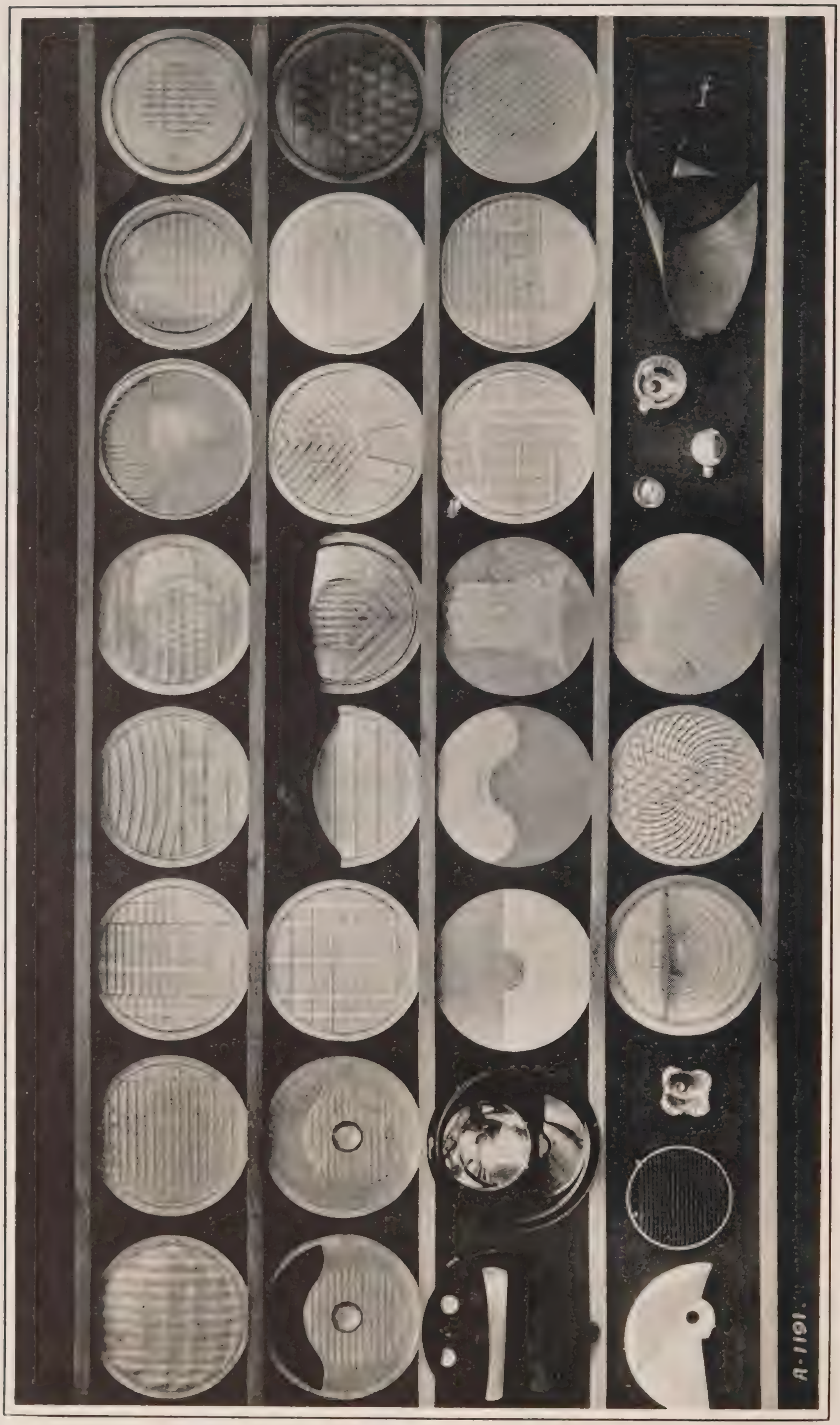


Figure 5—Some of the devices tested.

There are some designs of complete headlamps and reflectors that have for their purpose the production of a safe driving light. Some of these possess merit but the disadvantage of most of them is that they are very inefficient.

GENERAL REMARKS.

The results of our tests are issued to the public in the form of a list of approved devices. This list simply authorizes the use of the various devices under certain limitations of candlepower of lamp and elevation of beam. The stated values of these limitations are being commonly misinterpreted as ratings. A rating of any device of any kind is in the true sense of the word, an indication of performance and is usually also a measure of quality. A statement of the maximum candlepower permissible is not in any sense a rating. It has come to notice that the significance of these figures is being distorted for commercial use. As an instance of this a comparison of two makes of lenses is given. They are designated as A and B merely for convenience. "A" is allowed a slightly higher candlepower than B and is being advertised as a better lens.

CANDLE POWER AT POINTS

	A	B	C	D	E	F	Lamp
Device A	2815	6660	1665	480	960	4680	21 C.P. Mazda C
Device B	4645	20870	1345	710	2225	14575	21 C.P. Mazda C

A comparison of these figures shows that B gives much more light on the road than A does but the candlepower of the point D is closer to the limit for B than it is for A. This is the only reason for the higher permissible candlepower of A. Furthermore, a device was tested that would require 67 candlepower lamps to produce the minimum required at the point B. Now if 67 candlepower lamps were procurable this device would have been listed for such but even with such high powered lamps, the light produced on the road would have been only 23 per cent. of that produced by device B (above) with 21 candlepower lamps. The only guidance for the motorist is a trial to determine whether or not a device produces satisfactory illumination for himself.

There is one very important point that the tests described have brought out, that is, the lack of proper means for focusing and centering the lamps in headlamps as manufactured at present. Lamps with filaments accurately centered in the bulbs are the rare exception rather than the rule. To properly focus a lamp the filament must be at or very near the axis of the reflector and if the filament is not in the centre of the bulb the only alternative is to move the whole lamp across the axis of the reflector until it is in the proper position. We have been unable to find one make of headlamp that provides this adjustment. Our testing headlamps had such an adjustment applied as a special feature.

Until lamp manufacturers produce lamps with accurately centered filaments or headlamp manufacturers provide for lateral adjustment the securing of the most satisfactory results with non-glare devices will be

attended with more or less difficulty.

The writer wishes to acknowledge the courtesy of Hon. F. C. Biggs, Ontario Minister of Public Works, Mr. W. McLean, Deputy Minister, and Professor A. T. Laing, Consulting Engineer, for permission to publish the description of the tests carried out at the Laboratories of the Hydro-Electric Power Commission of Ontario.

There are 84 electric utilities in the state of California, operating 75 hydro-electric plants and 50 steam plants.

Canada's barley yield is 64,275,000 bushels, as compared with 56,381,000 bushels in 1919.

An Error

The Editor regrets that our printers took the liberty of transferring H. G. Hall from Ingersoll to St. Mary's without previous notice of their intention. This notice was published in THE BULLETIN last month through an error. We trust that this obvious mistake caused no one any inconvenience.

Canada's oat crop is a record one this year—more than two bushels of oats will be threshed to every bushel of wheat. The estimated crop is 550,000,000 bushels, which is 85,000,000 bushels more than the previous record crop in 1915.

Association of Municipal Electrical Utilities

The dates of the next Convention will be

January 27 and 28, 1921

Be in Toronto on those dates

Hydro News Items

Niagara System

CHATHAM—The Chatham Public Utilities Commission has arranged to purchase from the Chatham Gas Company, three gas-engine-driven generators. These machines have a total capacity of approximately 450 horsepower and are being used to relieve power shortage conditions on the local Hydro System.

DUNDAS—George Whiton, Superintendent of the Dundas Public Utilities Commission, and A. W. Goodes, Dundas System Operator for the Provincial Commission, leave in November for Chicago where they intend taking up the garage business. These men have been connected with the Hydro System for many years and they are the type of men we will miss. We wish them every success in their new venture.

Eugenia System

KINCARDINE—The construction of a distribution system in this municipality is progressing favorably and the work is being performed under the supervision of the local superintendent with the assistance of the Commission's engineers.

A sub-station building is also being constructed by the Municipality for the purpose of housing the equipment supplied by the Commission in connection with service from the Bruce County extension of the Eugenia System.

LUCKNOW—A distribution system is being constructed in this municipality by the Construction Department of the Commission and it is expected that this will be completed for service on or about December 1st.

RIPLEY—Instructions have been issued and material ordered and delivered covering the construction of a distribution system in this municipality for the purpose of taking power from the Bruce County extension of the Eugenia System.

It is expected that the system will be ready for service some time during the month of December.

SOUTHAMPTON—The Commission's engineers have completed a valuation of the development and transmission system of the Saugeen Light & Power Company, Southampton, and the Commission is negotiating the purchase of same with the company for the purpose of serving Port Elgin and Southampton. When this plant is taken over it will be parallelled with the Eugenia System and operated in connection with this System.

TEESWATER—A distribution system is being constructed in this municipality by the Construction Department of the Commission and it is expected that same will be ready for service on or about December 1st.

This municipality will be served by the Bruce County extension of the Eugenia System.

TIVERTON—A request has been received by the Commission from the Village of Tiverton, which is located a few miles north of Kincardine, for estimates for Hydro-Electric service. An investigation is being made covering delivery of power to this Municipality.

WALKERTON—The Commission has completed a valuation of the Walkerton Electric Light & Power Company's development and transmission systems and the Commission is negotiating the purchase of this property for the purpose of serving Walkerton and parallelling same with the Eugenia System, which will greatly benefit delivery of power in the Bruce County district.

WINGHAM—A sub-station is being constructed in this municipality by the Commission for the purpose of serving Wingham with Hydro-Electric power from the Bruce County extension of the Eugenia System.

It is expected that the station will be ready for service on or about December 1st.

Wasdell's System

KIRKFIELD—Crushed Stone, Limited, is considering the installation of additional equipment and estimates are being prepared covering delivery of 300 horsepower to the company. The acquisition of this load has been of great benefit to the Wasdell's System in general and the additional load will make this company the largest consumer on the Wasdell's System.

St. Lawrence System

ALEXANDRIA—The local distribution system has been completely overhauled and rebuilt. A system of ornamental street lighting has been installed on the main street. The 300-Kva., pole type transformer station is at present under construction.

APPLE HILL—The present 110-volt direct-current distribution system is being rebuilt for 4,000-volt distribution. A modern street lighting system will also be installed.

CORNWALL—Requests have recently been received for an additional supply of 10,000 horsepower to serve manufacturing plants in the town.

LANCASTER—A 4,000-volt single-circuit line is being constructed to connect the village with the sub-station at Martintown. A new distribution and street lighting system is in the course of construction.

MAXVILLE—The new distribution and street lighting system to adequately serve the needs of the municipality has been completed.

WILLIAMSBURG—A 50-Kva., pole-type sub-station is being erected to serve this municipality and the surrounding district. Power was formerly obtained over a 2,300-volt 3-phase line from Morrisburg.

WINCHESTER SPRINGS—The rate-payers have passed Enabling and Money by-laws providing for a supply of Hydro-Electric power. Work in this connection will be commenced very shortly.

Thunder Bay System

PORT ARTHUR—The terminal station building for receiving Nipigon power at Port Arthur has been completed and the equipment is now being installed in it. The transmission line between Nipigon Development and Port Arthur has been practically completed and work is progressing favorably on the Development at Cameron's Falls.

Rideau System

KEMPTVILLE—The village officials will shortly submit by-laws to the rate-payers with a view to securing a supply of power from the Rideau System, over a proposed 4,000-volt line from Merrickville to Kemptville.

Christmas Selling Campaign in Full Swing

The Christmas selling slogan, "Say Merry Christmas Electrically," has jumped into popularity almost over night. This is the slogan being spread broadcast by central stations and electrical merchants taking part in the Society for Electrical Development Holiday Campaign.

The Society has conducted many campaigns in the past, but from present indications this 1920 Christmas drive promises to eclipse all previous selling movements. As in previous campaigns, the Society supplies a certain amount of advertising material free to its members. Non-members, however, are required to pay only the actual cost of producing and distributing the material which they may want to use. On November 15th, Society Headquarters reported that they had already received more cash in payment for campaign advertising material than they received either during "Electrical Prosperity Week" or "America's Electrical Week," the two biggest national campaigns ever inaugurated by any industry.

It has already been necessary, so the Society reports, to order new supplies of several of the dealer helps. Nevertheless, there is still time for those who have not yet taken advantage of this campaign to get their material, and there is also an opportunity for those who under-estimated their requirements to get additional supplies of advertising folders, window cut-outs, poster stamps, etc.

Toronto has the world's largest annual Exhibition.

Association of Municipal Electrical Utilities

MINUTES of meeting of Executive Commitee, held on November 12, 1920. The meeting was called to order at 2.15 p.m., by Mr. O. H. Scott, President, others present being: Messrs. M. J. McHenry, H. F. Shearer, H. H. Couzens, R. H. Starr, A. T. Hicks, R. H. Martindale, O. M. Perry, J. J. Jeffery, L. G. Ireland, T. C. James, S. R. A. Clement, Secretary.

A letter from the Canadian Engineering Standards Association was read, asking for representation from this Association on a sub-committee on the Standardization of Meters. The Secretary was instructed to ascertain the action taken by The Hydro-Electric Power Commission of Ontario on this matter and to reply accordingly.

A letter from the Canadian Engineering Standards Association in reference to formulating a Canadian National Code was referred to the Regulations and Standards Committee for report.

A letter from the American Association of Engineers advising of a meeting for the purpose of taking steps toward forming an Engineering Council was ordered placed on file.

Plans for the next Convention of the Association were next taken up.

Moved by Mr. O. M. Perry, seconded by Mr. A. T. Hicks:—That the next Convention be held in Toronto on January 27 and 28, 1921. *Carried.*

Mr. H. H. Couzens, Chairman, Papers Committee, presented a report of a proposed programme for the Convention. It was decided that the following be presented:—

January 27th, p.m.—A paper on the "Economic Handling of Range and Heater Loads on Distribution Systems," by Mr. C. E. Schwenger, Toronto Hydro-Electric System.

January 28th, a.m.—Illustrated talks on the "Engineering Features of the Chippawa-Queenston Development," both hydraulic and electrical, by Messrs. T. H. Hogg and E. T. J. Brandon, both of the Hydro-Electric Power Commission of Ontario.

January 28th, p.m.—A paper on the "Examination, Testing and Approval of Electrical Appliances and Apparatus by the Ontario Hydro Laboratory," by Mr. W. P. Dobson, Hydro-Electric Power Commission of Ontario. It was also proposed in connection with Mr. Dobson's paper to arrange for visits to the Hydro-Electris Power Commission's Laboratories, on the mornings of January 27th and 29th.

A written report by Mr. V. S. McIntyre, Chairman of the Conventions Committee, was presented. This report suggested menus for an Association Dinner to be held at the Walker House, and also the name of Hon. I. B. Lucas as speaker at that dinner.

The Secretary was instructed to obtain, if possible, Professor Stephen Leacock to speak at the dinner, and also to arrange to hold the dinner at the Carls-Rite Hotel.

There being no further business, the meeting adjourned at 4 p.m.

HYDRO MUNICIPALITIES

NIAGARA SYSTEM

Acton	1,563
Ailsa Craig	447
Ancaster	400
Ancaster Township	4,621
Aylmer	2,177
Ayr	809
Baden	710
Barton Township	8,029
Beachville	503
Biddulph Township	1,763
Blenheim	1,533
Bolton	675
Bothwell	700
Brampton	4,238
Brantford	28,725
Brantford Township	8,061
Breslau	500
Brigden	400
Burford	700
Burford Township	3,845
Burgessville	300
Caledonia	1,150
Chatham	15,030
Chippawa	1,095
Clinton	1,948
Comber	800
Copetown	230
Dashwood	350
Delaware	350
Dereham Township	3,233
Dorchester	400
Dorchester S. Twp.	1,389
Drayton	622
Dresden	1,413
Drumbo	375
Dublin	218
Dundas	5,078
Dunnville	3,402
Dutton	858
Elmira	2,238
Elora	1,122
Embro	481
Etobicoke Township	6,586
Exeter	1,431
Fergus	1,609
Flamboro E. Twp.	2,443
Forest	1,418
Galt	12,558
Georgetown	2,010
Glencoe	865
Goderich	4,562
Grantham Township	3,242
Granton	300
Guelph	16,974
Hagersville	1,058
Hamilton	110,137
Harriston	1,381
Hensall	715
Hespeler	2,929
Highgate	379
Ingersoll	5,278
Kitchener	19,767
Lambeth	350
Listowel	2,437
London	58,421
London Township	5,744
Louth Township	2,214
Lucan	640
Lynden	662
Markham	813
Merritton	2,358
Milton	1,750
Milverton	929
Mimico	2,490
Mitchell	1,672
Moorefield	335
Mount Brydges	500
New Hamburg	1,356
New Toronto	2,551
Niagara Falls	12,434
Niagara-on-the-Lake	2,014
Norwich	1,262
Norwich N. Twp.	2,011
Norwich S. Twp.	1,814
Oil Springs	548
Otterville	400
Palmerston	1,815
Paris	4,866
Parkhill	1,202
Petrolia	2,954
Plattsville	500
Point Edward	984
Port Colborne	2,987
Port Credit	1,100
Port Dalhousie	1,391
Port Stanley	732
Preston	4,966
Princeton	600
Ridgetown	2,180
Rockwood	520
Rodney	656
Sandwich	3,448
Sarnia	12,178
Scarborough Twp.	6,566
Seaforth	2,027
Simcoe	3,818
Springfield	426
St. Catharines	19,189
St. George	600
St. Jacobs	400
St. Mary's	3,807
St. Thomas	17,209
Stamford Township	3,702
Stratford	17,143
Strathroy	2,687
Streetsville	475
Tavistock	917
Thamesford	388
Thamesville	808
Thorndale	250
Tilbury	1,623
Tillsonburg	2,788
Toronto	489,681
Toronto Township	4,782
Townsend Township	3,291
Vaughan Township	4 090
Walkerville	5,914
Wallaceburg	3,992
Waterdown	790
Waterford	985
Waterloo	5,105
Waterloo Township	6,378
Watford	1,133
Welland	9,876
West Lorne	700
Wellesley	583
Weston	2,495
Windsor	29,344
Woodbridge	600
Woodstock	10,051
Wyoming	495
Zurich	457
Total	1,122,752

SEVERN SYSTEM

Alliston	1,224
Barrie	6,775
Beeton	492
Bradford	866
Camp Borden	....
Coldwater	584
Collingwood	7,849
Cookstown	635
Creemore	615
Elmvale	600
Midland	7,339
Orillia	8,058
Penetang	3,664
Port McNichol	564
Stayner	870
Thornton	200
Tottenham	475
Victoria Harbor	1,496
Waubaushene	600
Total	43,006

WASDELL'S SYSTEM

Beaverton	932
Brechin	225
Brock Township	2,871
Cannington	818
Eldon Township	2,085
Gamebridge	70
Kirkfield	....
Mara Township	2,486
Sunderland	570
Thorah Township	1,116
Woodville	400
Total	11,573

NIPISSING SYSTEM

Callander	650
Nipissing	100
North Bay	9,413
Powassan	519
Total	10,982

MUSKOKA SYSTEM

Gravenhurst	1,502
Huntsville	2,113
Total	3,615

EUGENIA SYSTEM

Alton	450
Artemesia Township	2,392
Arthur	1,027
Chatsworth	257
Chesley	1,703
Derby Township	1,577
Dundalk	700
Durham	1,500
Elmwood	350
Flesherton	378
Grand Valley	558
Hanover	3,225
Holstein	285
Horning's Mills	350
Kilsyth	....
Markdale	925
Mount Forest	1,716
Neustadt	412
Orangeville	2,173
Owen Sound	11,768
Shelburne	970
Tara	520
Total	33,486

OTTAWA SYSTEM

Ottawa	104,007

THUNDER BAY SYSTEM

Port Arthur	15,100

CENTRAL ONTARIO SYSTEM

Belleville	12,345
Bloomfield	500
Bowmanville	2,853
Brighton	1,387
Cobourg	4,835
Colborne	939
Deloro	347
Deseronto	2,117
Kingston	23,737
Lindsay	7,880
Madoc	1,146
Millbrook	746
Napanee	2,864
Newburgh	426
Newcastle	552
Omemee	467
Orono	700
Oshawa	9,748
Peterborough	20,904
Picton	3,257
Port Hope	4,311
Stirling	823
Trenton	6,107
Tweed	1,292
Wellington	802
Whitby	3,471
Total	114,556

ST. LAWRENCE SYSTEM

Brockville	9,418
Chesterville	925
Prescott	2,660
Williamsburg	200
Winchester	1,047
Total	14,250

RIDEAU SYSTEM

Carleton Place	3,844
Perth	3,545
Smith's Falls	6,356
Total	13,745

ESSEX COUNTY SYSTEM

Amherstburg	2,386
Canard River	50
Cottam	333
Essex	1,753
Harrow	619
Kingsville	1,567
Leamington	3,907
Total	10,615

THOROLD SYSTEM

Thorold	4,325

Frequencies: Niagara and Thorold Systems—25 cycles; all other Systems—60 cycles.

THE aim of The Bulletin is to provide municipalities with a source of information regarding the activities of the Commission; to provide a medium through which matters of common interest may be discussed, and to promote a spirit of co-operation between Hydro Municipalities.